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Ljungström AIR PREHEATER

MAR 24 '26

THE Ljungström AIR PREHEATER

PATENTED

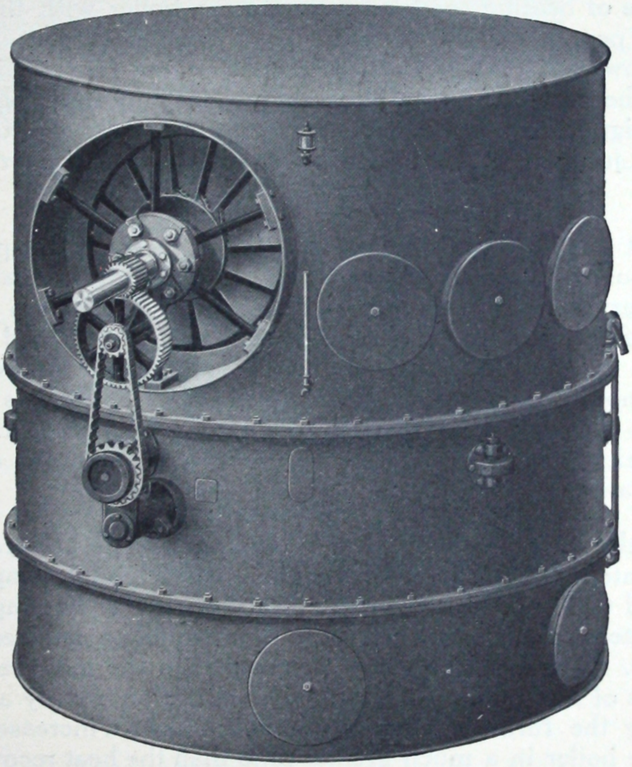

Fig. 1. EXTERNAL VIEW.

Manufactured by

THE AIR PREHEATER CORPORATION

25 Broadway, New York

Works—Wellsville, N. Y.

BULLETIN A-11

STACK LOSS AND HEAT RECOVERY

THE GREATEST source of loss in connection with steam boiler operation is the quantity of heat carried away in the flue gases through the stack. Development in connection with modern boiler plants has considerably increased the pressures and ratings at which the boilers operate. This naturally results in increased stack temperatures, and in order to obtain a good overall efficiency, it becomes imperative to provide some means for recovering a greater part of the stack loss, which frequently amounts to 10 to 25%.

Several years ago economizers were introduced for the purpose of reducing the stack loss by means of heating the feed water to the boiler with the flue gases, and in this way a certain percentage of the waste heat was recovered. With the increased boiler pressures, however, very serious difficulties are encountered in designing suitable economizers, and the cost of upkeep also becomes an important item. Were the economizer to be redesigned to recover a percentage of stack loss equal to that which is possible with the Ljungström Air Preheater, its size would be beyond commercial possibilities.

Therefore it has become common practice in many power plants to preheat the feed water to the boiler by means of "bleeding" steam from the main turbines, and this system, which is very simple in design and operation, gives from 4 to 6% increased overall efficiency of the power plant beyond that which is obtained directly by preheating the air. When feed water heating by stage bleeding is employed, naturally the usefulness of the economizer becomes practically negligible. This is also the case when sufficient quantities of exhaust steam from auxiliaries or steam that has been applied to various manufacturing processes in digestors, dryers, evaporators, etc., is available for heating the feed water.

Therefore, the logical solution lies in the use of air preheaters to extract a greater part of the heat contents of the waste gases, thereby raising the temperature of the combustion air supplied to the boiler. The practical benefits of heating the air instead of heating the feed water are considerably greater than would be deduced from simple arithmetical calculations. The advantage does not stop with the mere return to the furnace of a certain amount of heat units per hour. The hotter air supply also results in better combustion, raising the furnace temperature, which in turn increases the rate of radiant heat transfer to the boiler in a much greater ratio than the heat recovery, the absorption increasing with the fourth power of the absolute furnace temperature.

In order to justify the adoption of air preheaters, it is most important that these embody practical working principles and designs so that the maximum heat transfer is obtained. The Ljungström Air Preheater differs materially from all other air preheaters because it employs the ***regenerative*** principle, i. e., the heat is carried from the escaping flue gases to the incoming air continuously, in a mechanical way, by means of a slowly rotating regenerator containing a ***very large heating surface*** within narrow limits. At the same time also the ***counterflow*** principle is applied.

In this manner, a very efficient Air Preheater has been developed and the Ljungström Air Preheater herein described has been standardized for an average recovery of 70% of the sensible heat in the flue gases.

GENERAL DESCRIPTION OF THE LJUNGSTRÖM AIR PREHEATER

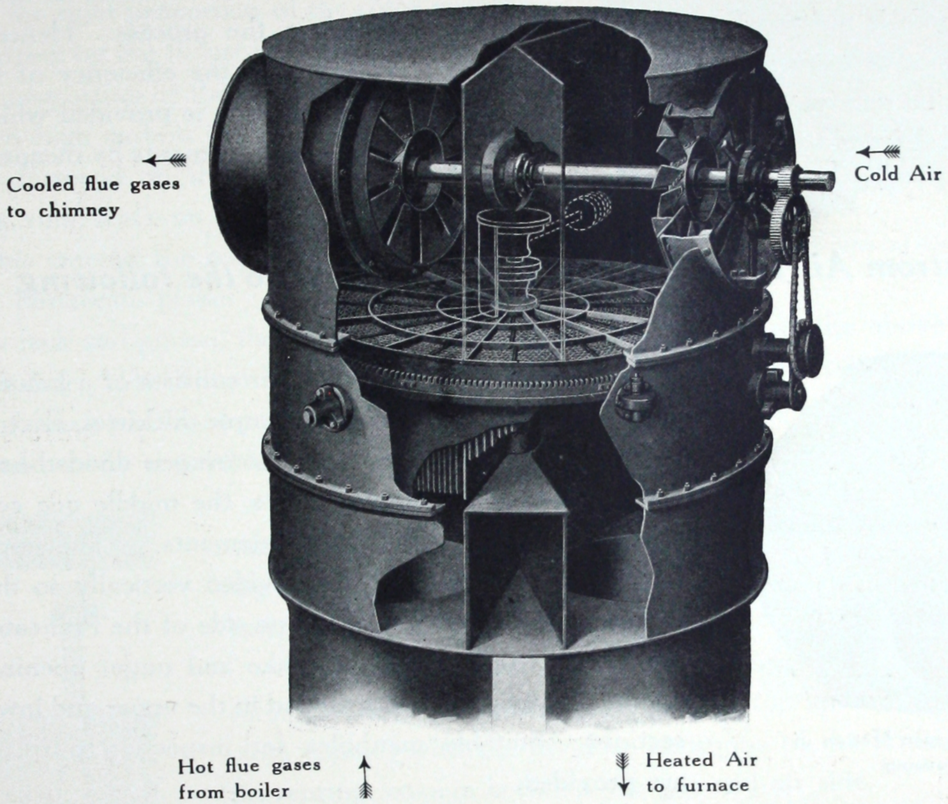

Fig. 2. INTERNAL VIEW.

REFERRING to Figure 2, fresh air is drawn by a fan into the upper portion of the casing, which is divided in two parts by a vertical partition. The air is confined to one side of the partition and passes downward through a porous cylindrical drum or rotor, to a similar semi-circular chamber in the lower part of the housing. Flue gases from the boiler traverse the apparatus in a reverse way, entering the lower semi-circular chamber on the opposite side and passing upward through the rotor to the upper chamber, whence they are exhausted and impelled to the stack by another fan.

The rotor is kept in a state of continual slow rotation so that the part heated by the flue gases is continually passing to the other side of the heater, giving up its heat

GENERAL DESCRIPTION

(Continued)

to the cold air which sweeps through it. Similarly, of course, the cooled part of the rotor is continually returning to be reheated by the flue gases. It will be observed, therefore, that there is no transference of heat ***through*** metal in the process. Hence a deposit of soot or tarry matter will have practically no effect on the efficiency of the apparatus. To remove all deposits a specially designed soot blower is provided which, without interference with the operation, cleans the rotor in a few moments by means of steam jets.

Ljungström Air Preheaters are built according to the following general specifications:

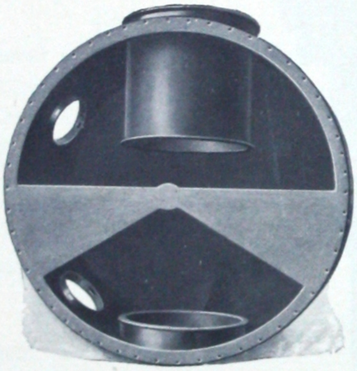

Fig. 3. Upper Section of Housing

Housing: The Preheater consists of a housing constructed from steel plates of ample thickness, electrically welded at all joints. This housing is divided horizontally into three compartments, the middle one containing the rotor with heating elements. The upper and lower compartments are divided vertically so that the flue gases are confined to one side of the Preheater, and the air to the other. Intake and outlet openings for the air and gases are arranged in the upper and lower sections. Suitable manholes for inspection purposes are provided.

Rotor: The frame work of the rotor is built up from steel plates, all joints being electrically welded. A number of sections, formed by radial dividing plates, house the heating elements. The rotor revolves from two to four times a minute.

On the smaller sizes of Preheaters, the weight of the rotor is carried by a seamless rolled, high carbon, heat-treated, heavy steel ring, against which the carrying and guide rollers operate.

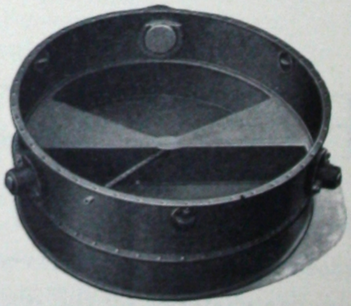

Fig. 4. Lower Section of Housing

On the larger Preheaters the weight of the rotor is carried principally in a heavy thrust bearing located in the top section of the Preheater. In this case the weight of

GENERAL DESCRIPTION

(Continued)

the rotor is balanced by two arms carrying counter weights. These can be adjusted so that the right proportion of the rotor weight is carried by the thrust bearing, while a certain proportion of the weight is carried by a rolled high carbon heat-treated heavy steel ring fastened on the outside of the rotor. This ring rests on three carrying rollers. In this manner the rotor is guided and kept in a horizontal plane. The rotor is driven by a rack and pinion, the rack being fastened to the top side of the above-mentioned steel ring. The thrust bearing and the bearings for the carrying rollers, together with the driving pinion, are all ball bearings, and so located that they are surrounded by cold air and easily accessible.

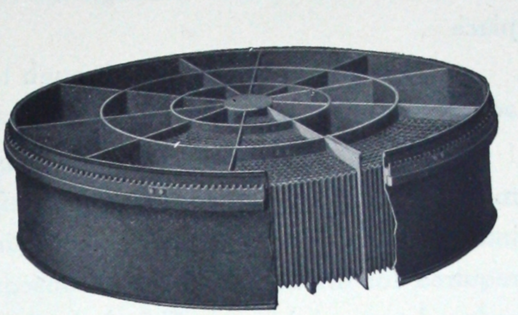

Fig. 5. Rotor in Course of Construction

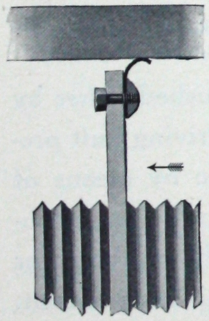

Fig. 6. Sealing Strip in Position

Due to the very slow speed of the rotor and the slight amount of friction in the ball bearings, the power required for turning the rotor is very small indeed. On a 1000 H. P. boiler, for instance, the actual power required is less than ¼ H. P.

Sealing Strips: Nickel steel sealing strips attached to the rotor dividing plates, and rotor ring at top and bottom, maintain close contact with the dividing partitions of the housing, thereby preventing leakage between the gas and air side.

Heating Elements: These consist of specially crimped steel plates of about 1/32″ thickness, alternating with plain steel sheets inserted concentrically and forming, when assembled, a honeycomb structure. In this manner a great number of channels or passages through the rotor are formed, and a very large heating surface is provided in an effective and inexpensive way for a Preheater of comparatively small dimensions. The heating surface of the Ljungström Air Preheater and also the cross sectional areas for gases and air have been experimentally ascertained under various conditions. The heating surface is generally made from three to four times that of the boiler to which it is applied. This, of course, results in a very effective cooling of the flue gases and heating of the fresh air.

The draft loss through the Preheater is very low owing to the liberal cross section areas and the comparatively short and straight passages, thus allowing the gases and

GENERAL DESCRIPTION
(Continued)

air an unobstructed flow through the rotor. No cross flow or change in direction takes place.

The normal resistance through the rotor amounts to about ½″ and therefore the added fan horse power required is practically negligible.

Fans: The principal dimensions of the encased axial type fans have been determined experimentally, so that a high efficiency is obtained. Further, as the forced and induced draft fans operate with cold air and cooled flue gases respectively, the power required for driving purposes is consequently reduced to a minimum. The pitch of the fan blades can be altered, which, in conjunction with the regulation of the speed of both fans, makes it possible to control closely the air supply and maintain a balanced draft in the furnace. The two fans are carried on a common high grade open-hearth steel shaft. Self-aligning ball bearings mounted in oil-tight housings are provided.

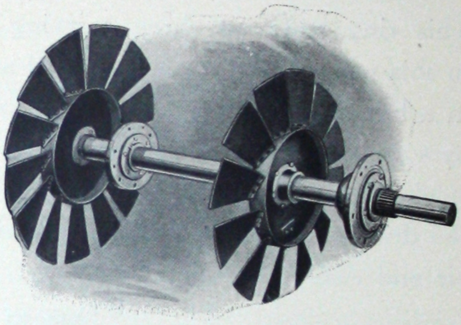

Fig. 7. Forced and Induced Draft Fans on one Shaft

Driving Mechanism: The motive power employed may be furnished either by steam turbine, steam engine, electric motor or from line shafting. The driving unit preferably should be direct connected to the fan shaft. The rotor is driven by means of suitable gearing from the fan shaft. Thus the speeds of the fans and the rotor are coordinated under all load conditions. As the rollers carrying the weight of the rotor are mounted on ball bearings, the amount of power for driving the rotor is insignificant. Suitable provision is made for adjusting the driving chain.

Soot Blower: This consists of two steam pipes, one above and one below the rotor, each having a nozzle-shaped narrow slot or a large number of nozzles suitably spaced in order to accomplish an effective sweeping of the elements. A specially constructed double soot blower valve is also furnished. This valve, which is automatically self-draining, admits only dry steam alternately through the two jet pipes. A complete blowing of the Preheater is effected in less than a minute, and usually the Preheater has to be blown once or twice a day.

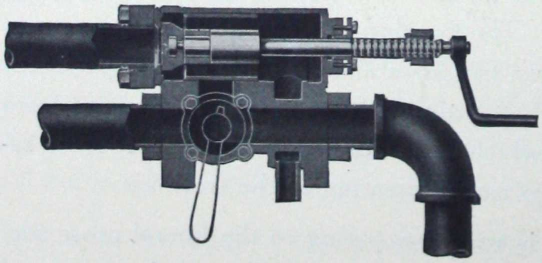

Fig. 8. Double Acting Soot Blower Valve

GENERAL DESCRIPTION

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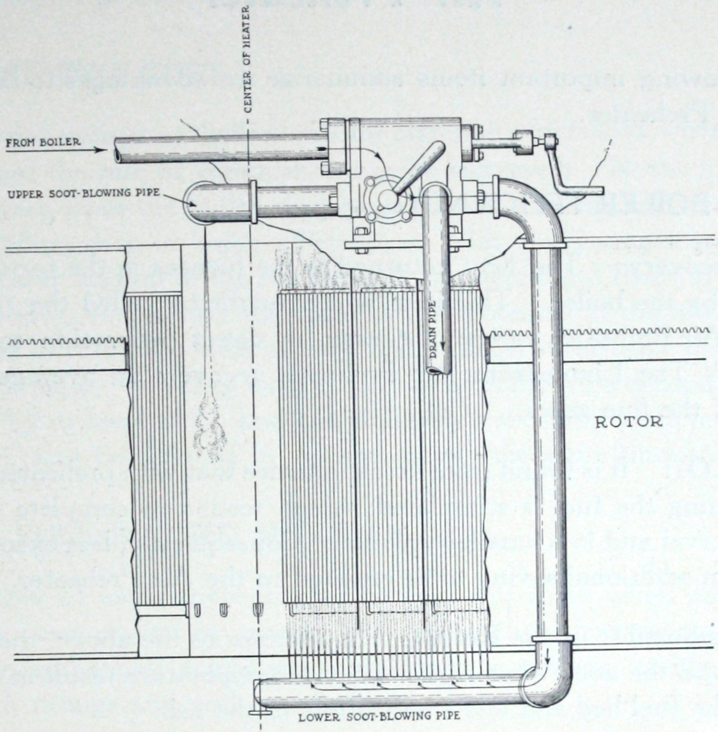


Fig. 9. Soot Blower
Showing Pipe and Valve Arrangements

Bearings: The carrying and guide rollers are made of high grade, heat-treated, carbon steel, mounted on ball bearings of very ample size. The oil tight housings for the ball bearings are affixed externally to the middle section of the Preheater and are entirely clear of flue gases or heated air. Oil cups are provided at all ball bearings.

Insulation: As the lower part of the heater comes into contact with the hot flue gases and the preheated air respectively, this is carefully lagged on the inside to reduce radiation losses to a minimum.

Chart of Lubricant Recommendations for Ljungström Air Preheaters

Part to be Lubricated	Method of Application	Lubricant
Fan Shaft Ball Bearings	Sight Feed Oil Cup	Gargoyle D.T.E. Oil Heavy Medium
Carrying and Guide Roller Bearings	Hand Oiled	
Open Gears and Chains	Hand Oiled	
Electric Motor Bearings	Ring Oiled	
Steam Turbine Bearings	Ring Oiled (temp. above 180° F.)	Gargoyle Cylinder Oil 600W
	Ring Oiled, water cooled	Gargoyle D.T.E. Oil Heavy Medium

Advantages Obtained with the Ljungström Air Preheater

The following important items summarize the advantages to be gained with the Ljungström Air Preheater.

INCREASE IN BOILER EFFICIENCY.

Heat Recovery: The heat returned to the furnace in the form of preheated air is fully utilized by the boiler. This item which might be called the theoretical saving effected by the Air Preheater varies, of course, in direct proportion to the amount of heat recovered. The Ljungström Air Preheater recovers an average of 70% of the heat contents of the flue gases.

Higher CO_2: It is found from actual practice that with preheated air the chemical reaction of burning the fuel is stimulated, which results in complete combustion in a shorter time interval and in a smaller volume. Consequently, less excess air is required. This results in an additional saving to be credited to the Air Preheater.

Less Combustible in the Refuse: In addition to the above, the increased speed of combustion and the somewhat higher furnace temperature result in a more complete combustion in the fuel bed and less combustible in the ash.

Less Difficulty with Poor Boiler Settings: On boilers having poorly constructed settings with insufficient height and furnace volume, the efficiencies are materially improved by the application of preheated air. Owing to the balanced draft conditions also obtained with the arrangement of fans in the Ljungström Air Preheater, losses due to air infiltration are reduced to a minimum.

INCREASED BOILER CAPACITY.

Increased Evaporation: The fuel saving might also be expressed in a different way, i. e., with the same quantity of coal burned with preheated air, a greater amount of steam will be generated in proportion to the corresponding fuel saving. If, for instance, the fuel saving amounts to 15%, this also means that the capacity of the boiler is increased by the same amount.

Increased Combustion Rates: It has also been found from actual experience that when preheated air is introduced to the furnace, it is possible to burn a greater amount of fuel on the same grate area. The ignition and rate of combustion are improved on account of the more favorable furnace conditions resulting from preheated air, which means that higher ratings can be obtained.

In powdered coal installations and with oil fired boilers, the use of preheated air makes it possible to burn more fuel per cubic foot of furnace volume, which means that with a given furnace a greater capacity can be obtained than with cold air.

LOWER INVESTMENT COST.

Commercial ratings on boilers can be materially increased when preheated air is employed, because the rate of combustion can be increased. At the higher ratings, the uptake temperature from the boiler, and consequently the stack loss, increases rapidly with a corresponding drop in boiler efficiency. With the Ljungström Air Preheater, however, the greater amount of the stack loss is recovered and therefore the overall efficiency is improved to very nearly the same as that obtained at the lower ratings. This makes it possible to run the boilers at very high ratings, at the same time obtaining good commercial efficiencies. In other words, the size of boiler for a desired amount of steam can be reduced by at least 25%, and consequently the capital investment for boiler and boiler house can also be reduced by approximately the same amount.

LOW GRADE FUEL BURNED SUCCESSFULLY.

The benefit of using preheated air is very apparent when low grade fuel is burned. It has been proved in practice that when the Ljungström Air Preheater is used, low grade anthracite, screenings, culm, coke breeze, etc., can be burned very successfully at high ratings and with good efficiencies.

Other low grade fuels such as wet wood, refuse from saw mills and paper mills, peat and bagasse, can also be burned very satisfactorily with highly preheated air.

SPACE REQUIREMENTS.

Due to the very compact design of the Ljungström Air Preheater, it is possible to equip boilers with a very large air preheater surface. The Ljungström Air Preheater generally employs about three to four times the heating surface of the boiler itself and the space requirements are very much less than, for instance, those required by economizers. Therefore, the Ljungström Air Preheater makes an ideal installation on existing boilers. It is also possible to reduce the size of the proposed buildings in new installations by incorporating the Ljungström Air Preheater, together with the stage bleeding for heating the feed water, in the design of the power plant. Ljungström Air Preheaters are designed to be self-contained and do not require any expensive foundations.

FORCED AND INDUCED DRAFT FANS INCORPORATED.

In the Ljungström Air Preheater, axial type forced and induced draft fans are provided. These fans are mounted on a common shaft, which makes a very compact installation as compared with the separate fan arrangement heretofore used in power plants. The installation also greatly simplifies and reduces the cost of duct work and flues. The power consumption and the size of the fans is materially reduced because the air fan handles cold air and the induced draft fan the cooled gases. Due to the simple arrangement of the fans, balanced draft is obtained, which provides a proper forced and induced draft over a wide range with practically no separate damper control. Sufficient induced draft is provided by means of the fan, therefore there is no necessity for an expensive stack.

STOKER AND FURNACE CONDITIONS

With the Ljungström Air Preheater it is possible to obtain temperatures as high as 400 to 600° F. on the combustion air. The question has often been raised as to whether or not stokers and furnace settings can be designed to withstand such temperatures. An analogy may be drawn between the developments which have taken place to increase steam pressures and superheat temperatures in one case, and to increase furnace temperature and preheated air in the other case. Just as actual experiences have proved that boilers can be successfully designed for 1200 to 1400 lbs. with steam temperatures of 700°, so have a number of plants been operated most efficiently and successfully with Ljungström Air Preheaters giving air temperatures in some cases ***exceeding*** 600° F.

Developments in this respect have also been accepted by many stoker companies who now are prepared to guarantee their stokers to operate with air temperatures up to 750°.

Highly preheated air naturally increases the furnace temperature, but, as pointed out before, the radiant heat transmission to the boiler surface increases in a much greater ratio. Therefore the actual increase in furnace temperature amounts to only from 15 to 35% of the arithmetical rise in temperature of the combustion air. Tests and careful observations over extended periods prove that the cost of upkeep of furnace and stokers remains practically the same when using cold or preheated air. It would appear that a reducing flame and combustion close to the brick work is more detrimental to furnace settings than high temperatures. Favorable conditions in this respect are more easily obtained with preheated air than without. High grade fire bricks are now guaranteed for considerably higher temperatures than are obtained in any furnace, and they will give satisfactory service, providing a pure oxidizing flame is maintained.

With boilers running at very high ratings, provisions have now frequently been made to include water screens, air cooled furnace walls, etc., and these designs, which have been developed for cold air, also work very satisfactorily with preheated air.

We therefore emphasize that in modern power plants the best commercial results will be obtained with the Ljungström Air Preheater for heating the combustion air to the highest temperature, at the same time heating the feed water close to the saturated steam temperature of the boiler by taking full advantage of suitable stage bleeding.

Installation—with Underfeed Stokers

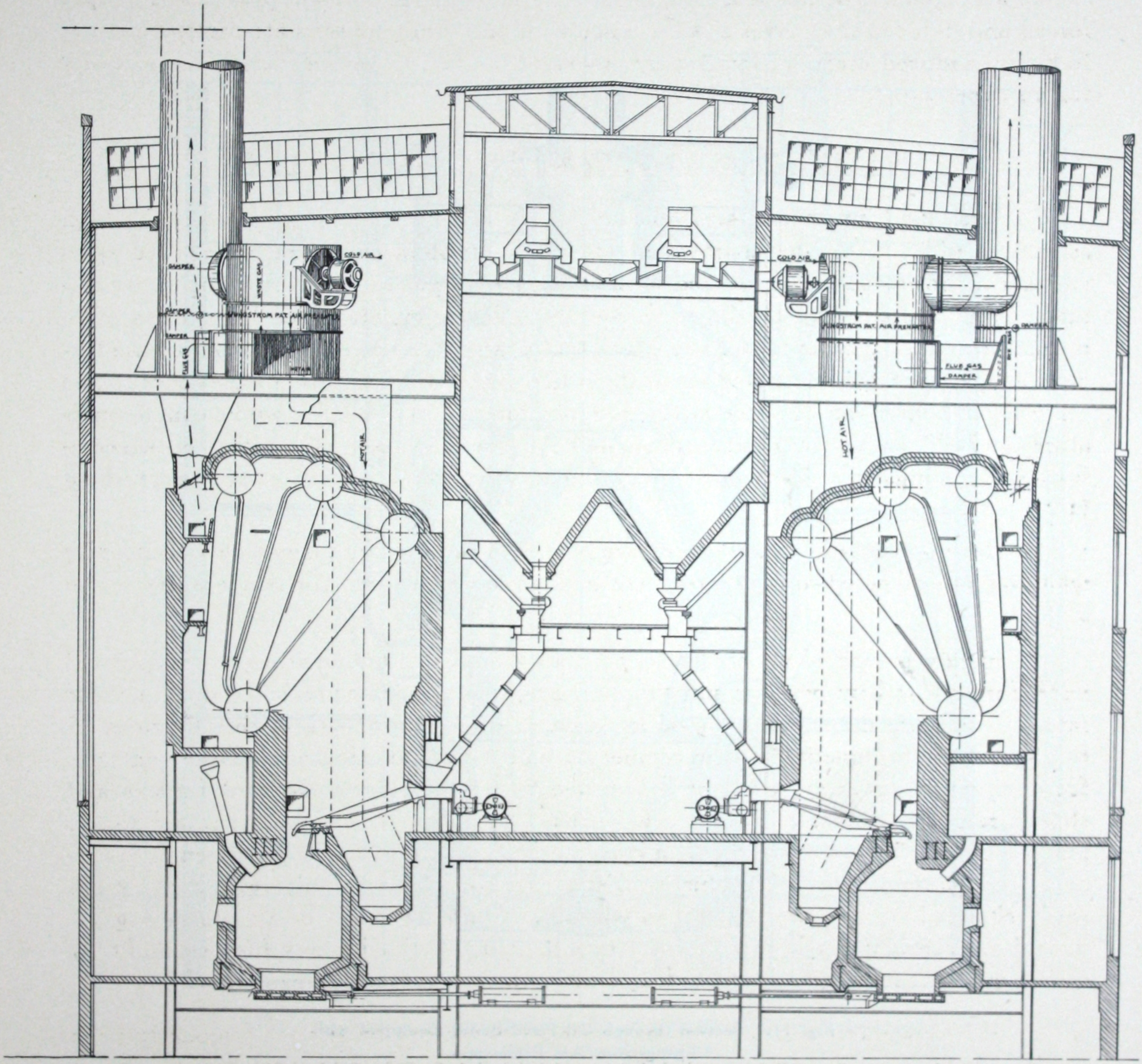


Fig. 10. Section View of Modern Power Plant Equipped with Ljungström Air Preheaters

Various arrangements can be employed to suit conditions, for instance, one Preheater per boiler, two smaller Preheaters per boiler, or one group of Preheaters connected to a common breeching from one group of boilers.

Performance—with Bituminous Coal

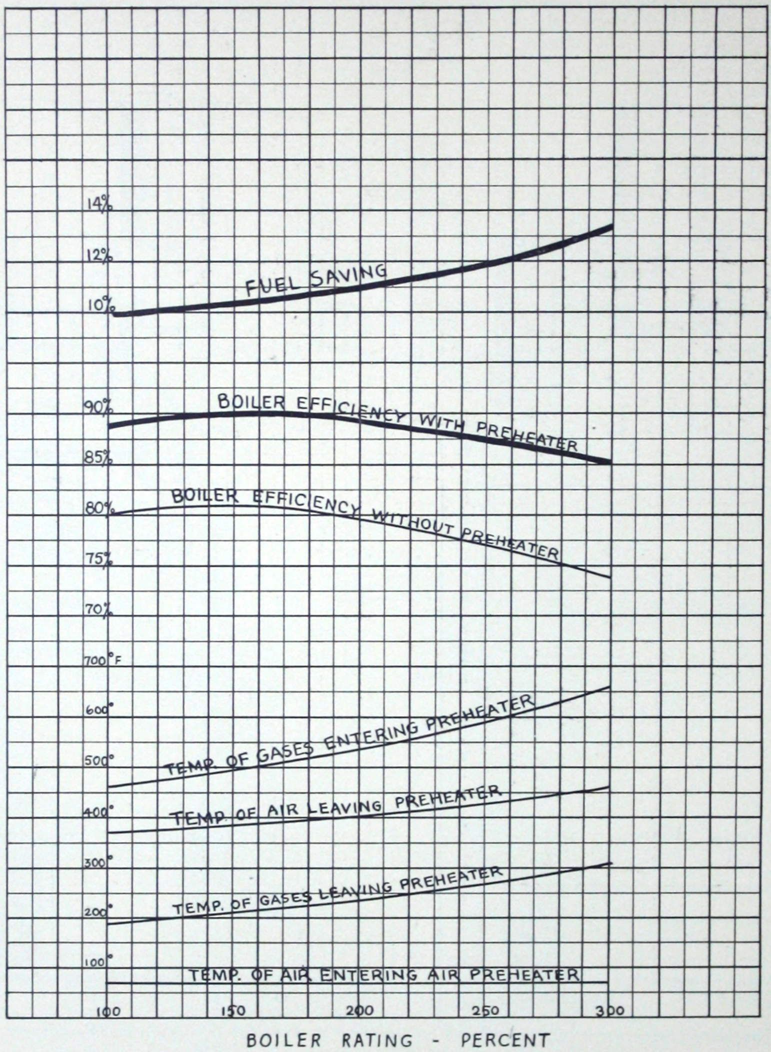


Fig. 13.

The above curves show performance of a Ljungström Air Preheater on a large cross drum water tube boiler equipped with superheaters but no economizer. The boiler is fired with Underfeed Stoker burning bituminous coal of 14,000 BTU's per lb.

It is interesting to note the high and very flat efficiency curve. The efficiency is maintained above 85% over the whole range of rating, and reaches a top value of slightly above 90%.

The fuel saving shown refers only to actual recovery of heat from the flue gases and no allowance is made for improved combustion, less combustible in ash, and the possibility of carrying a higher CO_2 when operating with highly preheated air.

Performance—with Pulverized Fuel

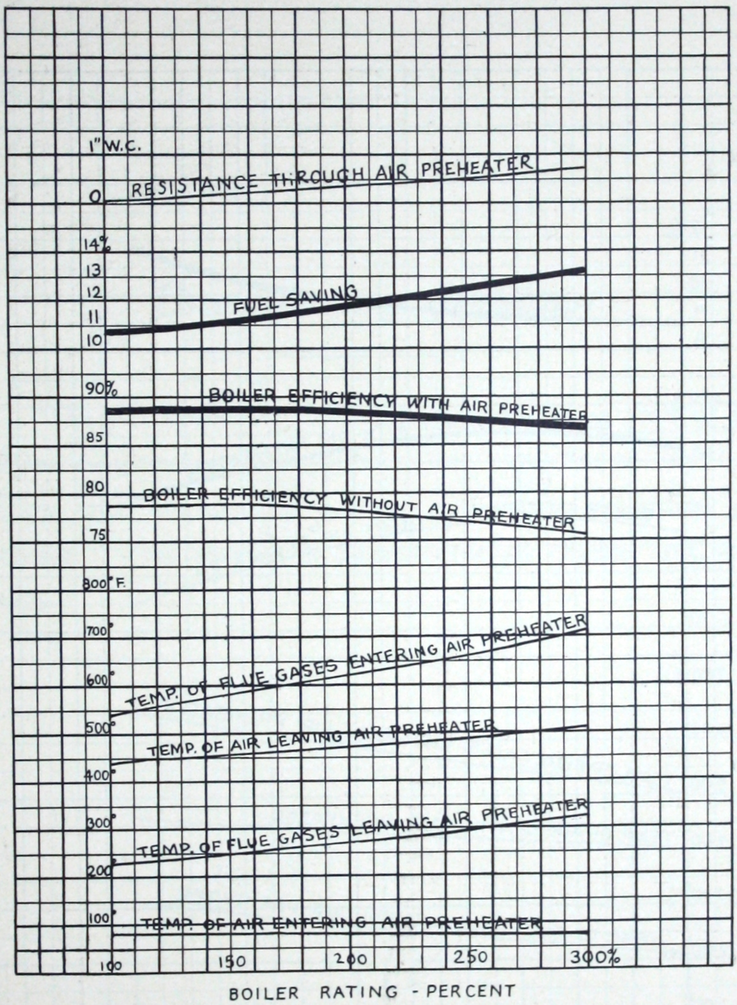


Fig. 14.

The above curves show the performance of a Ljungström Air Preheater on a large cross drum water tube boiler, equipped with superheater but no economizer, for burning pulverized, low grade, Illinois coal of 11,000 BTU per lb.

The boiler efficiency with the Air Preheater varies only 2% between 150% and 300% of boiler rating, and is remarkably high for this kind of coal.

It should be noted that no credit is given to the possibility of operating with higher CO_2 with maintained complete combustion when highly preheated air is used.

Performance—with Oil

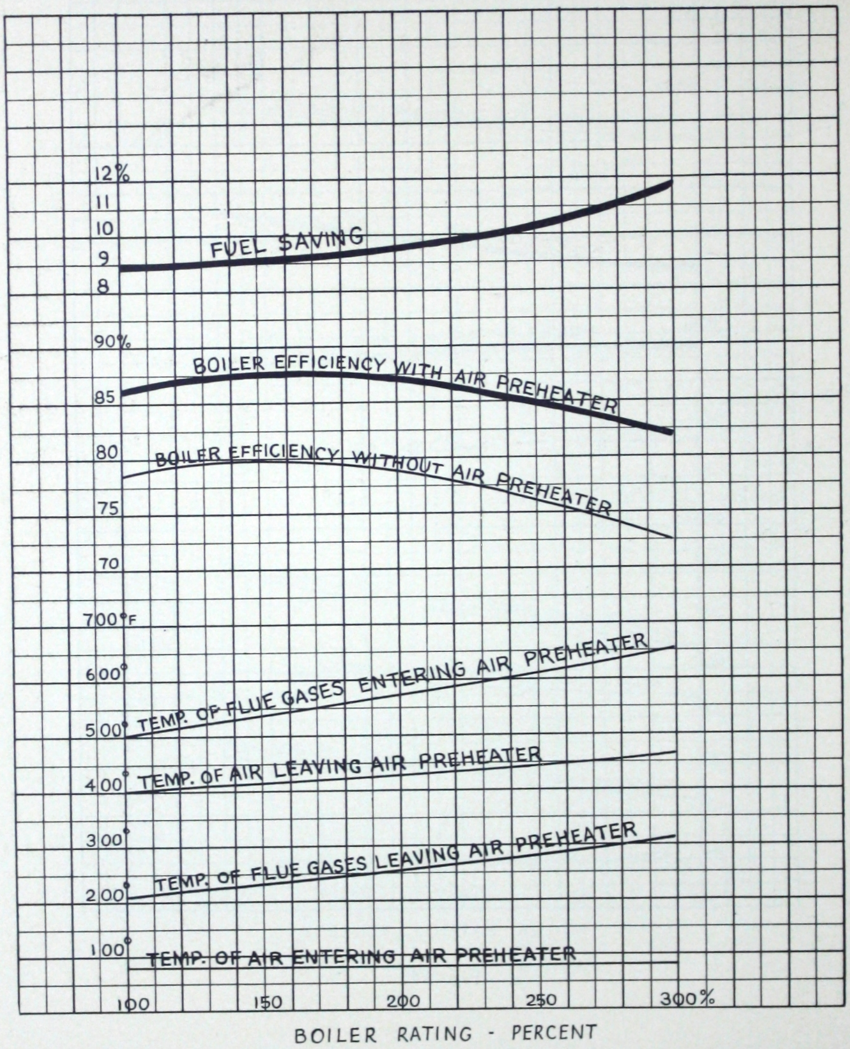


Fig. 15.

The above curves show the performance of a Ljungström Air Preheater on an oil fired, cross drum water tube boiler equipped with superheater but no economizer.

The use of highly preheated air greatly increases the capacity of oil fired boilers because preheated air has the same effect as an increase in furnace volume which allows complete combustion of considerably more oil in a given furnace.

Engineering Service

The Air Preheater Corporation maintains a staff of expert combustion Engineers, whose services are available at any time in connection with engineering matters and advice regarding power plant design. This service is offered free of charge and without obligation.

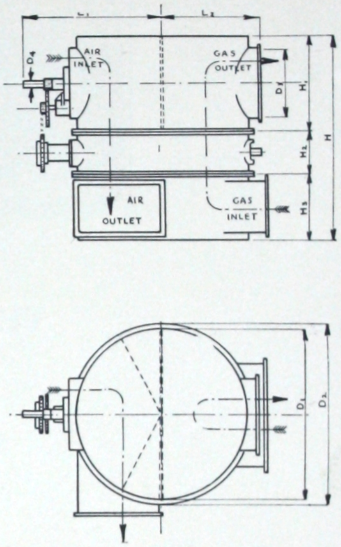
Dimension Table of Ljungström Patent Air

AIR PREHEATER TYPE			C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11
Air Preheater Dimensions		D_1	2′ 6″	2′ 9″	2′ 11″	3′ 2″	3′ 6″	4′ 0″	4′ 5″	4′ 8″	5′ 2″	5′8½″	6′ 3″
		D_2	2′ 9″	3′ 0″	3′ 3″	3′ 6″	3′ 10″	4′ 2″	4′ 9″	5′ 0″	5′ 6″	6′0½″	6′ 7″
		D_3	1′ 2″	1′4½″	1′5½″	1′ 7″	1′ 9″	1′10½″	2′ 0″	2′ 2″	2′ 4″	2′4¾″	2′ 9″
		D_4	1¼″	1¼″	1¼″	1⅜″	1⅜″	1⅜″	1½″	1½″	1½″	2″	2″
		L_1	1′ 10″	2′0¼″	2′ 2″	2′ 4″	2′5½″	2′ 8″	3′ 2″	3′ 4″	3′ 7″	4′ 0″	4′ 3″
		L_2	1′ 6″	1′ 7″	1′8½″	1′ 10″	2′ 0″	2′2½″	2′ 5″	2′ 8″	2′ 11″	3′ 1″	3′ 5″
		H_1	1′ 9″	1′ 11″	2′0½″	2′ 2″	2′ 4″	2′ 6″	2′ 7″	2′ 11″	3′ 0″	3′ 1″	3′ 4″
		H_2	1′8½″	1′8½″	1′8½″	1′8½″	1′8½″	1′8½″	1′ 10″	1′ 10″	1′ 10″	2′2¾″	2′ 3″
	Arr. A	H_3	10½″	11½″	12½″	1′ 2″	1′ 3″	1′4½″	1′ 7″	1′ 9″	1′ 11″	2′3¼″	2′ 5″
		H	4′ 4″	4′ 7″	4′9½″	5′0½″	5′3½″	5′ 7″	6′ 0″	6′ 6″	6′ 10″	7′ 7″	8′ 0″
	Arr. B	h_3	6″	6″	6″	7″	7″	7″	10″	10″	10″	1′ 0″	1′ 0″
		h	3′11½″	4′1½″	4′ 3″	4′5½″	4′7½″	4′9½″	5′ 3″	5′ 7″	5′ 11″	6′3¾″	6′ 7″
Heating Surface of Preheater		SQ. FT.	1248	1550	1870	2280	2810	3430	4200	5110	6220	8000	9800
Area of Hot Air Duct		SQ. FT.	0.80	0.99	1.22	1.45	1.80	2.2	2.8	3.3	4.0	4.9	6.0
Normal Speed of Fans		R. P. M.	2500	2400	2270	2150	2000	1900	1800	1700	1600	1500	1420
Power Consumption (Standard Fan)		H. P.	0.75	0.9	1.1	1.4	1.7	2.0	2.5	3.0	3.7	6.0	7.5
Approx. Weight		LBS.	2000	2200	2600	3100	3700	4400	5400	6600	7900	9600	11700

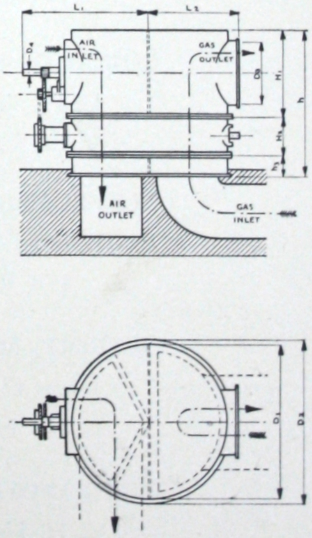
Preheaters—Type C and CA

C-12	C-13	C-14	C-15	C-16	CA-17	CA-18	CA-19	CA-20	CA-21	CA-22
6′ 10″	7′6¼″	8′2½″	9′ 0″	9′11½″	11′ 2″	12′ 3″	13′ 8″	14′10″	16′ 5″	18′ 1″
7′ 2″	7′ 10″	8′7¼″	9′ 4″	10′3½″	11′7½″	12′ 9″	14′1¾″	15′ 4″	16′11″	18′ 7″
3′ 0″	3′ 2″	3′7¾″	3′10¼″	4′6½″	5′1½″	5′7½″	6′ 2″	6′ 11″	7′ 5″	8′ 4″
2″	2½″	2½″	3″	3″	4″	4″	4½″	4½″	4¾″	4¾″
4′ 6″	5′ 2″	5′ 6″	6′ 0″	6′ 11″	7′ 3″	7′ 10″	8′ 3″	9′ 3″	10′ 3″	11′ 1″
3′ 9″	4′1¼″	4′ 5″	4′ 11″	5′ 5″	6′ 0″	6′ 7″	7′ 4″	8′ 1″	9′ 0″	9′ 9″
3′ 7″	3′11¼″	4′4½″	4′8¼″	5′2¾″	6′1¾″	6′ 7″	7′ 3″	8′ 1″	8′ 6″	9′ 7″
2′ 3″	2′3½″	2′3½″	2′4¾″	2′4¾″	3′4¼″	3′4¼″	3′ 7″	3′ 7″	4′ 4″	4′ 4″
2′ 10″	2′10¾″	3′ 2″	3′ 6″	4′0½″	4′ 3″	4′8¾″	5′ 3″	5′ 9″	6′ 4″	7′ 0″
8′ 8″	9′1½″	9′ 10″	10′ 7″	11′ 8″	13′ 9″	14′ 8″	16′ 1″	17′ 5″	19′ 2″	20′11″
1′ 0″	1′ 6″	1′ 6″	1′ 8″	1′ 8″	2′ 0″	2′ 0″	2′ 4″	2′ 4″	2′ 10″	3′ 0″
6′ 10″	7′8¾″	8′ 2″	8′ 9″	9′3½″	11′ 6″	11′11″	13′ 2″	14′ 0″	15′ 8″	16′11″
12000	14700	17700	21600	26700	37200	45700	56000	68700	84000	105000
7.3	8.8	10.7	13.3	16.1	19.8	24.2	28.4	36.5	45.0	54.6
1330	1270	1200	1160	1040	940	850	780	700	620	570
9.0	11.0	13.5	16.5	20	23	30	37	45	50	70
14300	17000	20500	25400	29800	42000	55000	69000	86000	110000	135000

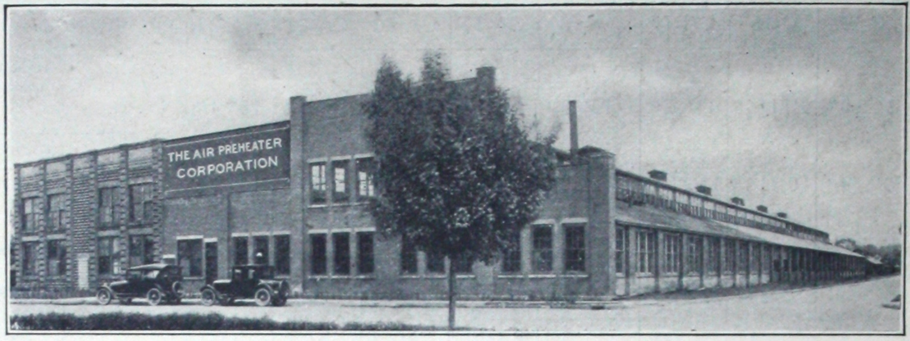
ARRANGEMENT A



ARRANGEMENT B



Ljungström AIR PREHEATER



Factory of

THE AIR PREHEATER CORPORATION

WELLSVILLE, N. Y.

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